U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News BULLETIN

VOLUME 47 | MAY 1963 | NUMBER 5

U.S. DEPARTMENT OF COMMERCE LUTHER H. HODGES, *Secretary*

NATIONAL BUREAU OF STANDARDS A. V. ASTIN, *Director*

NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Subscription price, domestic $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 19, 1961).

May 1963 Issued Monthly Vol. 47, No. 5

Contents

COVER: Schlieren image of a methane-air flame used to determine flame speeds by the total-area method in an NBS study of the effect of methyl bromide inhibitor on flame speed. In this photo of the inner core of the flame, the visible image is on the outside and the schlieren image on the inside. Halogenated hydrocarbons have long been used to extinguish fires, but study of their effects on flame speed has long been neglected.

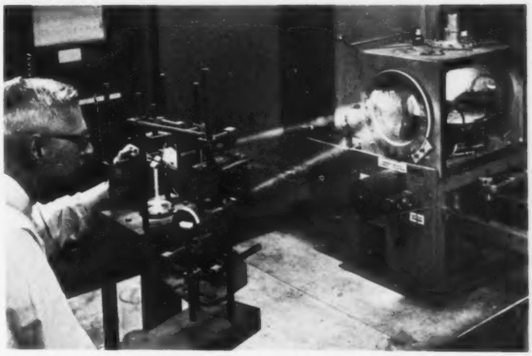
Effect of Methyl Bromide on Flame Speed of Methane

HALOGENATED hydrocarbons have long been used to extinguish fires. The effects of these inhibitors on combustion have been widely investigated, but study of their effects on flame speed has generally been neglected. Recently, however, Carl Halpern of the combustion controls laboratory investigated the effects of a methyl bromide inhibitor on the flame speed of a methane-air mixture under controlled experimental conditions.[1] Results indicate that, in the concentration range studied, maximum flame speeds are reduced in proportion to the amount of methyl bromide added.

Ideally the velocity of burning should be independent of the apparatus used, but the differing values reported in the literature indicate that determinations are affected by equipment. Since these values cannot be considered to be true burning values with any degree of accuracy, the term *flame speed* is used here rather than *true burning velocity*. The true burning velocity is defined as the velocity of propagation of a flame perpendicular to the flame front and relative to the unburned mixture.

The present study employed apparatus previously developed for use with methane-air mixtures.[2] The main feature of this equipment is a nozzle burner which produces a stable Bunsen-type flame. Two separate metering systems, one for the air plus inhibitor and one for the fuel, are used to introduce the mixture to the burner assembly. Here, after passing through a heating and calming chamber, the unburned mixture emerges from the nozzle at practically uniform velocity.

Separate manometer systems used for metering and controlling the rates of flow of methane fuel and of air-plus-inhibitor. The manometers comprising the fuel metering system are at left center; those comprising the air-plus-inhibitor metering system are at right center.



Double-pass noncoincidence schlieren system used to photograph flames. Recent studies with this apparatus show the effect of a methyl bromide inhibitor on the flame speed of a methane–air mixture. Maximum flame speeds are reduced proportionately to the amount of inhibitor added. Carl Halpern adjusts a prism to focus light from a mercury source on the first schlieren slit. After passing through the flame in the combustion assembly (*right*), the light impinges on a mirror and is reflected to the second schlieren stop (*left foreground*). It then passes through a lens to a 35 mm camera (*not shown*). Within the steel box (*right*) are a circular calming chamber and a nozzle burner. The pipe on top of the assembly is used to remove gases produced during combustion.

Mixtures of 0.1, 0.2, 0.3, 0.4, and 0.5 percent by volume of methyl bromide in air were prepared. For each mixture, the variation of flame speed with mixture ratio, by weight, of methane to air-plus-methyl bromide was determined. The ratio, by weight, of methane to air-plus-methyl bromide was varied from 0.054 to 0.072, and the gas velocity at the nozzle port was varied from 3 to 6 ft per second.

Flame speeds were determined by the total area method, which defines flame speed as the ratio of the volumetric flow of unburned gas (at the nozzle port) to the surface area of the flame. This surface area was obtained from measurements made on an enlarged photograph of the schlieren image of the flame.

Photographs of the schlieren and visible images were taken simultaneously on the same film. The schlieren image, which depends on the change in density and thus on the change in temperature, marks the position where chemical change begins in the flame; the visible image indicates the region in the flame where the reaction is completed. Therefore, the separation between the schlieren and visible images is a measure of the thickness of the reaction zone, which is found to vary with flame speed; the greater the flame speed the thinner the reaction zone. Also the reaction zone thickness increases as increased amounts of methyl bromide are added.

683615 O—63

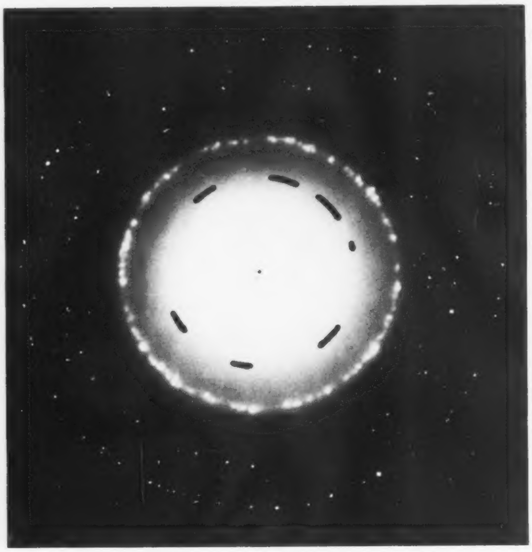
For each addition of methyl bromide and at each gas velocity, there was found one value of mixture ratio at which the flame speed was greatest. The addition of the methyl bromide to the combustion air reduced the maximum flame speed and the more methyl bromide added, the greater was this reduction. When values of maximum flame speed at each addition of methyl bromide, at constant gas velocity, were plotted against the percentage of methyl bromide, a straight line was obtained, indicating that the reduction in maximum flame speed is directly proportional to the amount of methyl bromide added.

The mechanism by which halogenated hydrocarbons, e.g., methyl bromide, inhibit combustion is not fully understood. The combustion of hydrocarbons in air involves the propagation of chain reactions by free radicals. Perhaps the presence of the halogen results in the deactivation of one or more chain-carrying radicals. Since deactivation would effectively decrease the rate of reaction, the general effect of the inhibitor in decreasing the flame speed would be explained. The increase in reaction zone thickness which results when methyl bromide is added may also be explained by the effective decrease in reaction rate.

[1] *For further technical details, see* Effect of methyl bromide additions on the flame speed of methane, *by Carl Halpern, J. Research NBS* **67A** *(Phys. & Chem.) 71–77 (1963)*.

[2] Measurement of flame speeds by a nozzle burner method, *by Carl Halpern, J. Research NBS* **60**, *535–546 (1958)*.

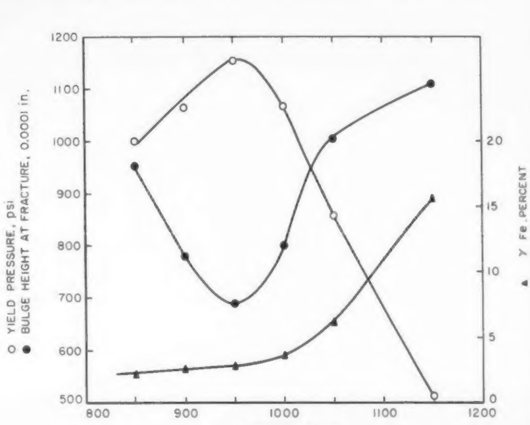
Hardening Mechanism in 17-7 PH Stainless Steel



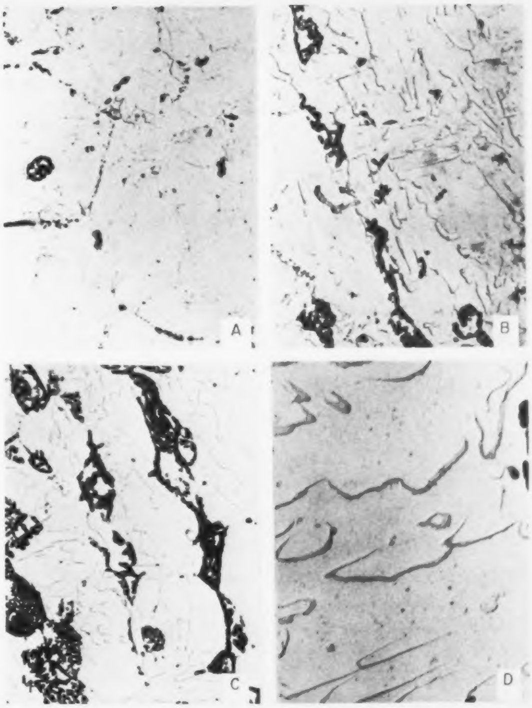
PRECIPITATION HARDENING stainless steels are widely used because of their high strength-density ratio, excellent corrosion resistance, and convenient forming characteristics. However, their acceptance has been hindered by difficulty in controlling their properties, partly because the mechanism of hardening has not been understood and the identity of the precipitating compound has not been established.

To determine the hardening mechanism, H. C. Burnett, R. H. Duff, and H. C. Vacher of the metallurgy laboratory recently investigated the metallurgical reactions occurring during the aging treatment of 17–7 PH (17 percent chromium–7 percent nickel precipitation hardening) steel and their relationship to changes in mechanical properties.[1] Their results show that increased hardening results from the precipitation of extremely fine particles of ordered ferrite during the heating treatment. They also found that the mechanical properties of the steel are improved by the reversion of some martensite (body-centered-cubic crystal structure) to austenite (face-centered-cubic structure) at temperatures above 970 °F.

Left: Investigation of the hardening mechanism of 17–7 PH stainless steel identified the hardening precipitate as ordered ferrite. This electron diffraction pattern, obtained from an area in a carbon extraction replica, gave lines that corresponded to the cesium chloride body-centered-cubic crystal structure. To indicate the agreement of the locations of the short arcs with the lines representing the crystal lattice, dashed circles whose diameters were computed from the average value of the lattice constants for ordered ferrite have been drawn on the pattern. _Below:_ Effect of aging for 1½ hr at various temperatures on the strength, ductility and austenite content of 17–7 PH stainless steel. Reversals in the strength and ductility curves do not occur until after there is a slight increase in the austenite content, near 950 °F.



Electron micrographs of carbon extraction replicas of 17-7 PH stainless steel aged at 1050 °F show the changes in the constituents of the steel with aging: *A*, after ¼ hr; *B*, after 3 hr; *C* and *D*, after 68 hr. The large black areas in *A*, *B*, and *C* are $M_{23}C_6$ carbide; the small grey spots in *D* are ordered ferrite, the precipitate responsible for the increased hardening of the steel.
Magnification: *A*, *B*, *C*, ×6250; *D*, ×25,000.



As is usual in the treatment of precipitation hardening steel, samples of the 17–7 alloy, which had been annealed at 1950 °F for ½ hr, were conditioned (heat treated) at 1400 °F for 1½ hr. After conditioning, the samples were rapidly cooled to room temperature. The samples were then given aging treatments in which both temperature (850 to 1150 °F) and time-at-temperature were variables.

It is well established that the soft condition of 17–7 PH steel consists mainly of austenite. During the conditioning treatment, carbides of the $M_{23}C_6$ type (where $M_{23}C_6$ is the structure of the carbide with M indicating the metal, in this case chromium) are precipitated at the grain boundaries, thus depleting the austenite grains of carbon and chromium. With this change in the chemical composition of the austenite, the M_s temperature—denoting the point at which the austenite-martensite transformation starts—is increased from below room temperature to a point sufficiently high for austenite to transform to martensite upon cooling. This transformation results in higher strength properties for the steel. However, the aging treatment results in hardening greater than that expected from the austenite-martensite transformation. This increased hardening has been postulated to arise from the formation of a fine precipitate within the martensite grains during the final heat treatment.

In the NBS study, identification of the hardening compound formed during aging was accomplished by using an electron microscope to examine selected areas in carbon extraction replicas of samples aged for 68 hours. The diffraction patterns obtained showed the precipitate to be ordered ferrite with the cesium chloride body-centered-subic crystal structure.

Previous investigations had suggested the structure of the precipitation hardening compound but had not shown the relationship of the compound to improved strength and ductility of the steel. In the present study, bulge test equipment previously developed at the Bureau [2] was used to measure the strength and ductility of 0.0025-in.-thick disks of steel foil. Strength was defined as the pressure required to produce a predetermined bulge height; the bulge height at failure was taken as a relative measure of ductility. Changes in austenite content with heat treatment were calculated from relative integrated intensities of corresponding X-ray diffraction lines for the martensitic and austenitic forms.

Observations showed definite effects of varying the heat treating schedule on the mechanical properties and structure of the steel. The austenite content increased after aging treatments at 1050 °F but little or no change in austenite was observed after aging at 900 °F. Maximum yield pressure and minimum ductility were approached in a shorter time at 970 than at 900 °F. At 1050 °F the yield pressure quickly (½ hr) reached the maximum then slowly approached the minimum while the ductility quickly reached the minimum (½ hr) but nearly recovered the initial value in 1½ hr. The investigators concluded that the abrupt increase in strength and loss in ductility are caused by the immediate formation of the ordered ferrite constituent, but the subsequent rapid recovery of ductility and slower loss in strength are caused by a reversion of martensite to austenite. Below 970 °F—the M_s point—there is little or no recovery in ductility or loss in strength because the martensite is not transformed to austenite.

[1] *For further technical details, see* Identification of metallurgical reactions and their effect on the mechanical properties of 17–7 PH stainless steel, *by H. C. Burnett, R. H. Duff, and H. C. Vacher, J. Research NBS* **66C** *(Eng. and Instr.) 113–119 (April–June 1962).*

[2] Use of the bulge test for determining mechanical properties of stainless steel foil, *by David B. Ballard, ASTM Materials Research and Standards* **1**, *471–473 (1961)*; *also*, Method for determining the mechanical properties of metal foils, *NBS Tech. News Bull.* **45**, *No. 11, 194 (1961)*.

Accurate Coupler Calibration of Microphones at High Frequencies

Using Special Hydrogen-Retention System

Condenser microphone with protective cap removed to show diaphragm.

MORE ACCURATE pressure calibrations of condenser microphones in small couplers can now be made at frequencies to 20 kc/s. This improvement in high-frequency calibration results from the use of a special hydrogen-retention system developed by Walter Koidan [1] of the sound laboratory.

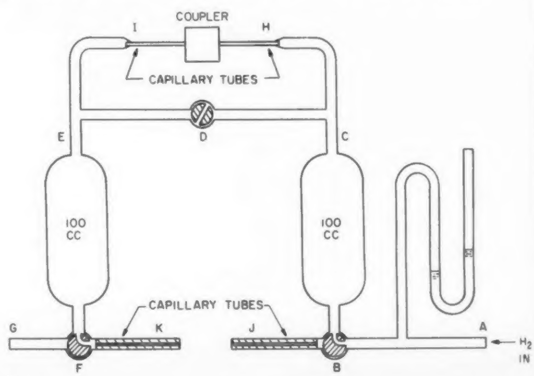
Calibrating a microphone [2] to be used for sound-pressure measurement consists in measuring its "pressure sensitivity" or "pressure response," which is the ratio of the open-circuit voltage produced by the microphone to the sound pressure uniformly applied over the exposed surface of the diaphragm. During a pressure calibration, two microphones are coupled to a cavity of known dimensions in which a sound field is generated by one of them. The other microphone acts as a sound receptor.

In the lower frequency range, where air is usually used as the coupling medium, the dimensions of the cavity are small compared with the wavelength of the sound, and the sound pressure is uniform throughout the cavity. This is not necessarily true at higher frequencies. However, if the air in the cavity is replaced with hydrogen, the wavelength at each frequency is increased by a factor of about 3.8. In this way, accurate calibrations can be made at higher frequencies. Capillary tubes connected to the coupler serve to maintain ambient pressure within the cavity and also permit the introduction of hydrogen.

In the usual procedure for making this type of microphone pressure calibration, the coupler is filled with hydrogen through one of its two capillary tubes and the air is ejected through the other. The concentration of hydrogen is determined by measuring the resonance frequency of a particular mode of the hydrogen-filled cavity and comparing this frequency with that obtained for the same mode when the coupler is filled with air. Because measurements must be made at ambient pressure to prevent changes in microphone response, the hydrogen supply must be cut off or removed during calibration. Air then displaces the hydrogen in the coupler at a rate determined by the volume of the coupler and the resistance of the capillary tubes. Readings are taken in order of decreasing frequency, so that the concentration of hydrogen is greatest at the highest frequencies.

This method has not been successful with couplers having volumes of about 3 cm³ or less because of the rapid loss of hydrogen. In a plane-wave coupler [3] in particular, the frequency of the first longitudinal mode, which is used in the calculation of the response, changes so quickly that the required plane-wave correction cannot be determined.

Hydrogen retention system results in more accurate coupler calibration of condenser microphones at high frequencies. With this apparatus, an adequate concentration of hydrogen at ambient pressure is maintained in the coupler. The system is operated as follows: stopcocks *B, D*, and *F* are first adjusted so that the hydrogen follows the path *ABCDEFG*, filling the 100 cm³ containers in a few minutes. Next, stopcocks *F* and *D* are turned to permit the coupler to be filled with hydrogen by the path *ABCHIEFK*. (The stopcock positions shown are in effect while the coupler is being filled.) Then *B* is turned so that the 100 cm³ container on the right vents to the atmosphere through capillary J. Finally, the hydrogen supply line is removed. Just before stopcocks *F* and *D* are turned, the supply pressure should be reduced to a very low value to prevent microphone damage resulting from excessive pressure in the coupler. The excessive pressure is caused by the resistance of the capillary tubes. As the coupler is being filled, the supply pressure should be kept below about 1 in. of water.



One way to overcome the difficulty of rapid hydrogen loss is to maintain a very small flow of hydrogen to prevent this resonance frequency from falling. But this flow produces a static pressure in the cavity that exceeds the ambient barometric pressure. The resulting pressure difference may cause a systematic error—which is difficult to evaluate—in the measured response.

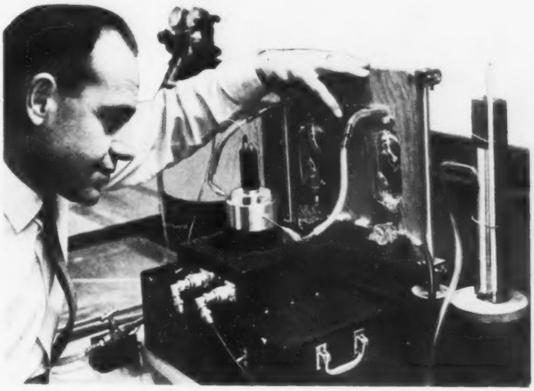
In the Bureau's method, this source of error is eliminated. Auxiliary hydrogen containers attached to the capillary tubes of the coupler maintain an adequate concentration of hydrogen. Ambient pressure is maintained in the coupler by additional capillary tubes that vent the containers to the atmosphere. An established procedure is followed to fill the coupler in such a way that the microphones are not damaged.

The hydrogen retention characteristics of the system depend, of course, on obtaining a good seal where the microphones rest on the shelves of the coupler. This seal can be accomplished with a thin film of vacuum grease on these contact surfaces.

[1] *For further details, see* Hydrogen retention system for pressure calibration of microphones in small couplers, *by Walter Koidan, Letter to Ed. J. Acoust. Soc. Am.* **35,** *No. 4, 614 (1963).*

[2] Calibration of microphones, *NBS Tech. News Bull.* **45,** *No. 11, 188 (1961).*

[3] Pressure calibration of condenser microphones above 10,000 cps, *by B. D. Simmons and F. Biagi, J. Acoust. Soc. Am.* **26,** *693–695 (Sept. 1954).*



Apparatus developed for use in accurate high-frequency calibration of condenser microphones in small couplers at ambient pressure. Marshall A. Pickett adjusts the control valve that permits hydrogen to enter the coupler. Ambient pressure and adequate hydrogen concentration are maintained through the use of the glass containers and associated capillary tubes. The relatively large capacity of the containers greatly reduces the hydrogen loss from small couplers so that a flow of hydrogen no longer need be maintained during a calibration. Such a flow would generate in the coupler an excessive static pressure that could result in a calibration error.

Correction

In the article describing the Ultrasonic Thermometer in the January 1963 issue (pp. 4–5) of the *Technical News Bulletin*, the factor 10^7 was omitted from the value of R_M. **The figure should properly read:**

$$R_M = 8.314 \times 10^7 \text{ erg/°C Mol.}$$

NBS Color Publications

NBS Circular 553, *The ISCC–NBS Method for Designating Colors and a Dictionary of Color Names*, is available again. This popular circular was out of print for about four months.

The dictionary is designed to assist the scientist, businessman, and layman in finding his way through the maze of color vocabularies used in the many fields of art, science, and industry. For instance, it will point out that Griseo-Viridis (biology) = Serpentine (fashion) = Mint Green (mass market).

Another NBS color publication has just been published. NBS Technical Note 152, *Coordinated Color Identifications for Industry*, gives five levels of fineness in identifying and specifying colors. The identifications are based on the ISCC–NBS system. Tech. Note 152 also lists the methods for changing from one level to another and gives examples of the use of each level.

Circ. 553 ($2.00) and Tech. Note 152 ($0.15) are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

STANDARD MATERIALS

New and Reissued Radioactivity Standards

FOUR NEW radioactivity standards—calcium 45, chlorine 36, iodine 125, and cerium 139—are now available from the Bureau.[1] Two previously available radioactivity standards—krypton 85 and a contemporary carbon for radiocarbon dating—as well as five radium rock standards, have been reissued as part of a continuing Bureau program to provide standard reference materials.

Radioactivity standards are distributed by the Bureau for calibrating and checking instruments employed in research, medicine, and industry. Calcium 45 (NBS Standard Sample No. 4942, price $38.00) is issued as a solution of calcium chloride in hydrochloric acid, and has a nominal activity of 8×10^4 d/s/ml (disintegrations per second per milliliter). Radioactive calcium is employed in medical and biological research.

Another new radionuclide gaining widespread use as a tracer in biological studies is iodine 125. This material (NBS Standard Sample No. 4944, price $24.00) is issued as a 5-ml solution with a nominal activity of 3×10^4 d/s/ml.

Chlorine 36 (NBS Standard Sample No. 4943, price $26.00) is supplied as a solution of sodium chloride in water, and has a half-life of 3×10^5 years. This radionuclide is used as a medium-energy long-lived performance standard for all types of beta detectors.

Reissued Radium Rock Samples*

Sample No.	Description	Average radium content picogram of radium per gram rock	Price per sample
4978	Columbia River basalt	0.33±0.03	$11.00
4982	Gabbro-diorite	.18± .02	$11.00
4983	Milford granite	.23± .02	$11.00
4984	Triassic diabase	.18± .03	$11.00
4985	Deccan trap	.21± .04	$11.00

*** *Each sample consists of 100 g of pulverized rock taken from bulk material analyzed for radium content. Petrographic data and the approximate chemical analysis of a representative sample of each rock are also given in a certificate accompanying each sample.***

New Radioactivity Standards

Sample No.	Nuclide	Activity as of date given	Form of standard	Price
4942	Calcium 45	8×10^4 d/s/ml Feb. 1, 1962	3 ml ampoule	$38.00
4943	Chlorine 36	10^4 β^-/s/g 1962	3 ml ampoule	$26.00
4944	Iodine 125	3×10^4 d/s/ml Jan. 1, 1963	5 ml solution	$24.00
4999	Cerium 139	5×10^4 γ/s Jan. 1, 1963	Solid point source	$32.00

Reissues of Previously Available Radionuclides

4935–B	Krypton 85	6×10^7 d/s/gm mol Oct. 1962	10 ml of gas	$23.00
4990–A	Contemporary carbon	No specific activity is given	1 lb of oxalic acid	$4.00

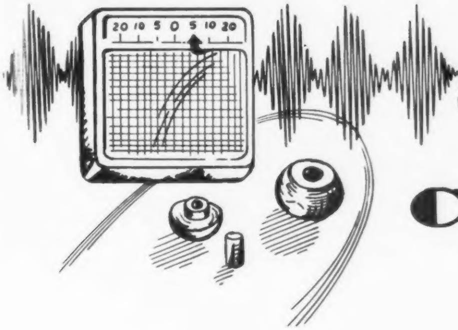
The cerium 139 standard (NBS Standard Sample No. 4999) will be of interest to all workers in gamma-ray spectroscopy by virtue of the single 166-kev gamma ray which follows the electron-capture transition. Cerium 139 is issued as a solid point source for $32.00.

NBS Standard Sample No. 4935–B is issued as 10 ml of krypton 85 gas at a price of $23.00. Krypton 85 is employed extensively in testing electronic tubes and other sealed components for leaks.

The contemporary carbon standard is issued as 1 lb of oxalic acid at a price of $4.00, and is used by biologists, geologists, and archaeologists as a reference for carbon dating of artifacts and biological specimens.

All orders for the radioactivity standards should be addressed to Miss E. Zandonini, Radioactivity Standard Samples, Radioactivity Section, National Bureau of Standards, Washington 25, D.C.

[1] *Standard materials issued by the National Bureau of Standards are described in NBS Miscellaneous Publication 241, Standard Materials. This publication may be ordered for 30 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Up-to-date supplementary inserts, which are issued periodically, are available upon request directly from the National Bureau of Standards.*



STANDARDS AND CALIBRATION

Interservice Measurement Audit

THE BUREAU is once again participating in the Interservice Measurement Audit of Primary Level Standards Laboratories. This audit is the fourth of a continuing series designed to promote measurement agreement among the military services. The items to be measured include two of each of the following: 10,000- and 0.01-ohm resistance standards; 1.0- and 0.01-pf capacitance standards; a frequency meter preset to a fixed frequency somewhere between 8 and 10 Gc/s; a 12-sided optical polygon; and a 0 to 2000 c/s virbration pickup. The initial measurements on these items are being made at the Air Force Calibration Division, Newark, Ohio after which they will be measured, in turn, at the Frankfort Arsenal (Army); Sandia Corporation, representing the Atomic Energy Commission; the Navy's Eastern Standards Laboratory; and NBS. The test results will be analyzed by the Air Force, which is acting as host for this particular audit.

Increasing Calibration Fees

THE COST of calibration, like that of just about everything else these days, is going up. Revised (upward) fees for most NBS calibration services are being prepared. The new fees will reflect the increased costs resulting from the recent pay raise for Federal employees. The fees charged by NBS are designed to recover the actual cost of the service rendered, but do not support the research necessary to provide improved measurement services. The new fees will be published in *The Federal Register* and notices carried in this column.

Precision Measurement Seminars

FIVE precision measurement seminars have been tentatively scheduled by NBS. Details concerning the seminars can be found on page 88 of this issue.

Recent Publications

In *NBS Viscometer Calibrating Liquids and Capillary Tube Viscometers* (NBS Mono. 56, 20¢), R. C. Hardy discusses the measurement of viscosity with widely used relative viscometers of the glass capillary tube type. The 10 oils (viscosities ranging from 0.02 to 450 poises) available from the Bureau for calibrating viscometers are described, and procedures and corrections applicable in the use of various types of viscometers are presented.

The various systems of electrical measurements, with their respective sets of units, are described in detail and their historical development summarized by Francis Silsbee in NBS Mono. 55, *Systems of Electrical Units* (30¢). The manner in which each system is derived is compared and contrasted from the viewpoint of both experimentalist and theoretician, the present status of the absolute measurements on which all electrical units are based is reported, and tables are included for the conversion of equations and numerical values from one system to another. Both of the above Monographs may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Experimenters at the Bureau's Boulder Laboratories are investigating the Stark effect as a means of making voltage measurements. This effect, which concerns the splitting of spectral lines by the application of an electric field, may lead to a means of measuring d-c and low-frequency voltages with high precision. A recent paper by Y. Beers and G. L. Strine of the Boulder staff, "Measurement of Voltage by the Use of the Stark Effect," appeared in the *IRE Transactions on Instrumentation*.

The January–March 1963 issue of Section C (Engineering and Instrumentation) of the Bureau's *Journal of Research* carries an article by Bernadine Dunfee on "A Method for Calibrating a Standard Volt Box" which describes the method used for measuring the ratios of the Bureau's standard volt box to an accuracy of 10 parts per million or better and discusses errors which might appear in such measurements.

NBS Laser Produces Interference Fringes

over 200-meter optical path

IN RECENT experiments at the Bureau, interference fringes were obtained with a modified Michelson interferometer over an optical path of approximately 200 m. This result, achieved by use of a helium-neon laser (**L**ight **A**mplification by **S**timulated **E**mission of **Ra**diation) as the infrared light source for the experiments, becomes significant when it is realized that interference fringes obtained by means of conventional light sources may be observed, at best, over paths of less than 2 m.

The present work was undertaken by T. Morokuma, K. F. Nefflen, T. R. Lawrence, and T. M. Klucher of the engineering metrology laboratory, to investigate the possibility of using lasers for accurate determinations of much longer distances.[1] At present, two separate measurement steps are required to determine the standard meter by means of the krypton 86 lamp whose 6057–Å spectral line is the international standard of length.[2]

With advances in modern technology, the need for accurate methods of measuring lond distances is constantly increasing, and the Bureau has been conducting intensive research to provide such methods. For example, the invar tapes used in surveying missile-tracking sites are now mechanically calibrated by the Bureau to about a part in a million. But if the present research results in the use of the laser as a standard light source, it is anticipated that this accuracy may be increased a hundred times.

Principal component of the Bureau laser is a light amplifier, an 80-cm-long discharge tube containing about 10 parts of helium to 1 part of neon. The tube is suspended horizontally between two curved partially transmitting reflectors, a meter apart.

When the helium atoms are excited to the lowest quantum-energy excited state (a metastable one) by power from a radio transmitter, they collide with ground-state neon atoms and resonant energy transfer takes place. One of the states of neon has nearly the same excitation energy as the helium metastable state, so the neon atoms are excited in the collision to a specific energy level, as the helium atoms return to the ground state. This mechanism creates a population inversion in the neon energy levels, since the lower excited states of neon are not populated by the process, and the inversion makes it possible for stimulated emission of infrared radiation to occur.[3]

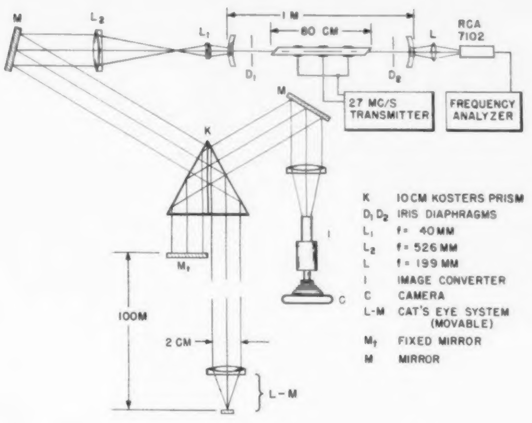
End windows on the discharge tube are sealed at such an angle that light with the correct polarization passes through the windows without reflection losses. This light is reflected back and forth by the two curved reflectors, and the amplitude of the light wave becomes greatly intensified by the stimulated emission. However, the intensity buildup occurs only for those light waves having a specific direction of propagation and whose wavelength, λ, is given by

$$\lambda = \frac{2\,L,}{n}$$

where L is the 1-m distance between the two reflectors, and n is an integer. In the present case, the wavelength obtained with the helium-neon tube is 11,523 Å in the infrared region of the spectrum.

The resonant frequencies formed by the two mirrors are separated by intervals of 150 Mc/s, corresponding to a wavelength separation of about 0.0075 Å, and the width of the spectral line is about 800 Mc/s. Therefore, laser oscillation can occur for a number of frequencies. However, when two diaphragms on both

Top of page: **Interference fringes observed over a 200-m optical path.** *Left:* **NBS deputy director, R. D. Huntoon** (*right*), **observes interference fringes produced by a helium-neon laser** (*left background*) **over a 200-m optical path. A. G. McNish** (*left*), **chief of the Bureau's metrology laboratories, points out part of the optical system used to obtain the fringes. T. Morokuma** (*right background*), **a guest worker from Japan, is monitoring the control panel.**

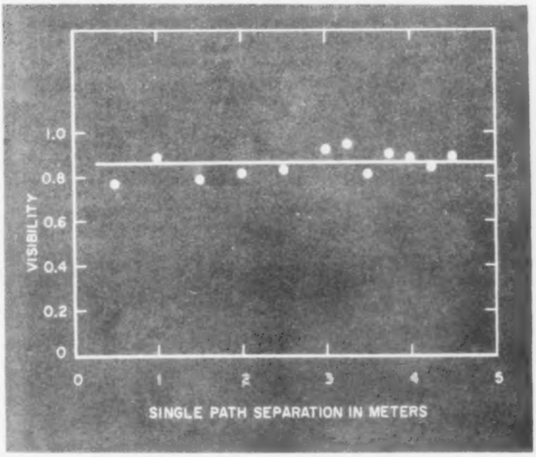


Experimental arrangement used to produce interference fringes over a 200-m optical path. A laser, consisting principally of an 80-cm-long helium-neon discharge tube (*top right center*), produces these fringes by means of a modified Michelson interferometer (*K, M_f, L–M*). An image converter (*I*) is employed to convert infrared wavelength to visible wavelength so that the fringes may be observed.

sides of the discharge tube are reduced to about 2 mm in diameter, the number of frequencies which are thus allowed to oscillate is limited to one or two. The spacing between the reflectors is then adjusted to obtain single frequency oscillation. The resultant light is highly monochromatic so that a coherent beam is produced.

This beam is reflected into an interferometer consisting of a cemented Kösters prism (which replaces the beam splitter and compensatory plate of a conventional Michelson interferometer); a reflecting flat-surface mirror positioned near the prism; and a "cat's eye" system positioned 100 m distant from the prism so that the reflected beam travels over the same optical path from and to the prism. The cat's eye consists of a lens and a mirror at the focal point of the lens. An image converter is used to convert the infrared wavelength to visible wavelength. With this converter, sharp fringes are observed when the beam images from the two mirrors coincide with each other.

Left: **Interference fringe visibility obtained with a laser light source over an optical path of several meters. Visibility remains virtually constant, as indicated by the straight line.** *Right:* **Coast and Geodetic Survey engineers employ an invar tape calibrated at the Bureau to measure the base line of a missile-tracking site at Cape Canaveral, Fla. Graduations on the tape are observed by means of a micrometer microscope placed over the tape on a concrete landmark (*center*). Another microscope, similarly placed, is 50 m away. Use of a laser method of length measurement—now under experimentation at the Bureau—to calibrate these tapes would greatly increase the accuracy of the measurements.**



Fringes obtained at various intermediate distances were recorded on film by a camera fitted to the image converter. Microdensitometer measurements of the visibility of these fringes showed that fringe visibility remained virtually constant over an optical path several meters long.

In the present experiments, fringes obtained at 200 m tended to be unstable, indicating that more work is necessary before 100-m lengths can be measured to a part in 100 million. For example, a reliable fringe counter must be adapted to the system to count the fringes automatically. Also, the wavelength of the laser oscillation must be stabilized and controlled; this wavelength depends on the spacing between the mirrors, and pickup of mechanical vibrations may cause mirror instability. Furthermore, a method for adjusting the laser to a precisely determined wavelength is required, and air currents and vibrations that cause instabilities in the light path of the Michelson interferometer must be eliminated.

[1] Interference fringes with long path difference using He-Ne laser, *by T. Morokuma, K. F. Nefflen, T. R. Lawrence, and T. M. Klucher, J. Opt. Soc. Am.* **53**, *394 (1963)*.

[2] Wavelength of Kr^{86} light becomes new international standard of length, *NBS Tech. News Bull.* **44**, *199 (1960)*.

[3] *In stimulated emission—the opposite of the more commonly observed absorption of radiation—a light wave of the appropriate wavelength traveling through the medium will increase, in contrast to the decrease that occurs in absorption.*

Automatic Thermocouple Comparator

THERE IS a growing trend at the Bureau to automate measurement processes wherever possible. Such automation helps the Bureau provide more rapid calibration service, and permits scientists more time in which to perform the research necessary for more accurate measurements.

Recently, a thermocouple comparator which automatically records data during the comparison calibration of platinum versus platinum-rhodium thermocouples was developed by John Evans of the temperature physics laboratory. This device, which places the data on punched tape prior to reduction by a computer, makes the calibration procedure more rapid and convenient and eliminates the errors which may occur during hand recording and transfer of the data. The comparator is similar to a design by Dauphinee.[1]

George Burns starts automatic thermocouple comparator which records on punched tape the emf of a standard platinum versus platinum-rhodium thermocouple, and the difference emf between this and up to 11 test thermocouples. Readings can be initiated by manual control, or automatically at preselected time or emf increments.

Platinum versus platinum-rhodium thermocouples submitted to NBS for calibration are, unless extreme accuracy is required, compared with an NBS standard platinum versus platinum-10 percent rhodium thermocouple. Such calibrations are made over the range 0 to 1450 °C by fusing one or more test couples to the standard and heating the common junction in an electric furnace. Prior to the development of this comparator, data were laboriously recorded by hand, or, if only four couples were being calibrated, recorded on a strip chart.

Use of the comparator permits automatic recording of the total electromotive force developed by the standard couple and the difference between this emf and that of as many as 11 test couples. The range factor of the amplifier used in conjunction with the difference readings, a constant emf to act as a reference check, and an instrument zero are also recorded.

The data can be recorded in several different sequences. One method is to set the comparator so that a complete set of readings is taken for every 0.5 mv change in the emf of the standard. Alternatively,

readings can be initiated by clock control at preselected time intervals or by manual control.

The comparator consists of circuitry for the emf and emf difference determinations and provisions for converting the data from analog to digital form for recording on the punched tape. Leads from both the standard and test thermocouples are connected to a selector, a rotary solenoid-driven switch. The temperature of the thermocouple junction is determined by measuring the emf of the standard with a self-balancing potentiometer indicator. The difference between the emf of the standard and that of a selected test thermocouple is obtained by means of an isolating potential comparator. The difference emf, after amplification, is also determined by means of a potentiometer indicator. Both the emf of the standard and the difference emf's are converted from analog to digital form by means of shaft position encoders attached to the indicators. These digital data are transferred to a storage and control section and then to the paper tape. The transistorized building blocks from which the storage and control sections are fabricated were designed by the Bureau's data processing laboratories.[2]

The data as recorded on the tape do not contain any decimal points. Therefore, the tape is run through an automatic typewriter which adds the decimals and puts the data in the proper format for computer input. A converter is then used to put the data on punched cards, after which it is reduced by a 7090 computer. The computer fits an equation to the difference between the test and standard thermocouple emf's, combines this equation with that used to compute temperatures from the standard's emf's, and computes the emf developed by the test thermocouple at one degree (either Celsius or Fahrenheit) intervals. Data at 1450 (if in °C) or 2618 (if °F) points can be furnished, rather than at 15 as previously given. As the computer printout itself is sent to the user, time is saved and errors avoided in the typing of calibration results.

---

[1] An apparatus for comparison of thermocouples, *by T. M. Dauphinee, Can. J. Phys.* **33**, *275 (1955)*.

[2] Transistorized building blocks for data instrumentation, *by J. A. Cunningham and R. L. Hill, NBS Tech. Note 68, available from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., $2.00.*

Humidity Affects Dielectric Properties of Polymers

A CURRENT study has shown that longtime exposure to varying humidity significantly affects the dielectric properties of certain polymers. This finding is directly related to the care of dielectric reference standards, and may be relevant to the use of polyethylene as insulation for underwater telephone and telegraph cable.

The study is part of a program being conducted by A. H. Scott and W. P. Harris of the dielectrics laboratory to develop standard reference specimens for dielectric measurements. The results obtained over a three-year period clearly demonstrate that specimens intended to serve as dielectric reference standards must be maintained under carefully controlled conditions and measured under these same conditions. In addition, the conditioning history of a specimen must be known if an accurate evaluation is to be made of its properties—no matter how uniform and stable the material.

The polymers investigated in this particular study were polyethylene, polystyrene, and polycarbonate. The first two materials have very low dielectric losses and are generally used where extremely good electrical insulation is required. The polycarbonate chosen for the study is a recently developed, extremely hard, tough material. It has moderate dielectric losses and has been found to have structural and electrical applications as an insulator. Other materials presently under investigation include fused silica, poly(1,4-cyclohexylene-dimethylene terephthalate), polytetrafluoroethylene, poly(methyl methacrylate), and iron-filled polytetrafluoroethylene.

The polymers were obtained in the form of circular disks. The polyethylene and polystyrene specimens were $1\frac{1}{2}$-in.-diam disks onto which metal electrodes

A. H. Scott inserts one of a group of polymer specimens into a humidity cabinet. One of each pair of duplicate specimens was kept in a dry atmosphere for up to six months and then placed in an atmosphere maintained at 52 percent relative humidity. The other underwent reverse treatment. At various time intervals over a 3-yr period, the dielectric constant and dissipation factor of each specimen were measured to determine the influence of humidity on these properties. The results are significant to the care and measurement of dielectric reference standards.

(usually gold) were evaporated. The polycarbonate specimens were about 3 in. in diameter without applied electrodes. One of a pair of duplicate specimens of each polymer was placed in a dry atmosphere; the other was placed in an atmosphere maintained at 52 percent relative humidity by means of a saturated salt solution. After about six months, the specimens were interchanged and the first set of measurements was taken using a three-terminal dielectric specimen holder designed and constructed at the Bureau.[1] Additional measurements were made in the same holder at various time intervals over a three-year period. The applied frequency was 1000 c/s at 23 °C, except when the influence of frequency was being studied.

The results indicate that the humidity effects are reversible. It is believed that no aging effect occurs because there is no overall unidirectional drift of property values (see graph).

Results on Individual Polymers

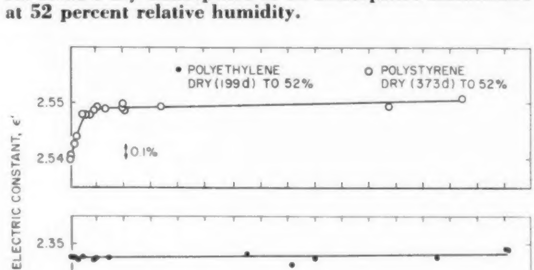
Polyethylene. Polyethylene showed less than a 0.1 percent change in dielectric constant after exposure of the specimen to the humid condition for up to three years. The dissipation factor for polyethylene increased from about 1.5×10^{-6} to values as much as 700 to 800 percent higher, in various cases, and was still rising after three years. This result relates to the use of polyethylene as insulation in a humid environment. The electrical properties of exposed polyethylene were little affected by frequency change.

Polystyrene. The dielectric constant of the polystyrene specimen increased about 0.4 percent after exposure to the humid condition. The dissipation factor, although initially greater than that for polyethylene, showed considerably less increase due to exposure. These properties were not noticeably influenced by frequency.

Polycarbonate. When the polycarbonate chosen for the study was exposed to the humid atmosphere, the dielectric constant increased about 2.5 percent and apparently approached equilibrium after about on month. The dissipation factor of this polymer ir creased rapidly when it was exposed to the humid cor dition. The curve of dielectric constant versus fr quency for exposed polycarbonate is simply uniforml shifted upward as a result of exposure to the humi environment. The curve of dissipation factor versu frequency for this polymer shows increases of about 1 percent at 100 c/s and 15 percent at 10^5 c/s over th values obtained for the same specimen in a dr atmosphere.

[1] Improved dielectric specimen holder for accurate measurements of standard reference specimens, NBS Tech. News Bull. **45**, No. 12, 210 (1961).

Variation of dielectric constant and dissipation factor with time for polyethylene and polystyrene after transfer from a dry atmosphere to an atmosphere maintained at 52 percent relative humidity.



Symposium on the Ionospheric Propagation of Very Low Frequency Electromagnetic Waves

A SYMPOSIUM on the Ionospheric Propagation of VLF Electromagnetic Waves will be held at the NBS Central Radio Propagation Laboratory, Boulder, Colorado, August 12 through 14, 1963. This will be a continuation of an earlier symposium on the Propagation of VLF Radio Waves held in 1957 at Boulder. The members of the Technical Program Committee are J. S. Belrose, W. T. Blackband, D. D. Crombie (Chairman), J. K. Hargreaves, R. A. Helliwell, A. G. Jean, and J. R. Wait.

The Symposium will be devoted to subjects of current importance in terrestrial VLF propagation, with emphasis on the effects of the ionosphere. Subjects will include mode theory, theory of formation and physical characteristics of the lower ionosphere, and observations of VLF propagation under normal and disturbed conditions. Most of the papers will be invited from leading workers in these fields but some short contributed papers will be given.

Further information about the Symposium is available from Mrs. D. Belsher, Secretary, VLF Symposium, National Bureau of Standards, Boulder, Colo.

Lattice Defects Studied in Copper Single Crystals

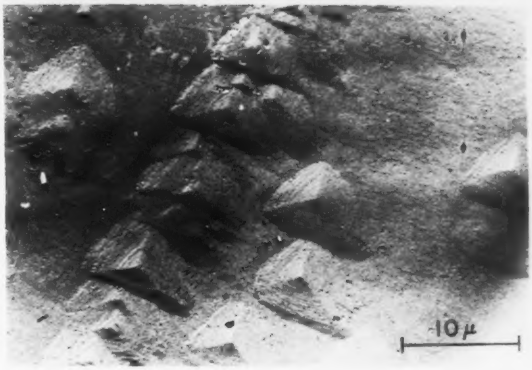
RECENTLY A. W. Ruff, Jr., of the metal physics laboratory investigated the reaction between chemical etch pits on a metal surface and defects present in the metal lattice.[1] In this work transmission electron microscopy was used to examine specimens made from single-crystal copper foils that had been exposed to a specific aqueous etching solution. Extended line defects in the metallic lattice known as dislocations, as well as etch pits extending into the metal surface, were readily discernible. The study showed that dislocations in these copper specimens are preferentially attacked by the solution, but that all dislocations do not give rise to pits, as had previously been believed.[2, 3]

Dislocations have an important effect on the mechanical properties of metals, and considerable research has been undertaken in the past few years to attempt their characterization. Sometimes an etching method has been employed to locate these defects emerging on the metal surface, and thus to relate surface pitting to substructure. However, a direct correspondence has not been conclusively established for metals. The present work was therefore undertaken to determine whether such a relationship could be found by a combination of chemical etching and electron microscopy techniques.

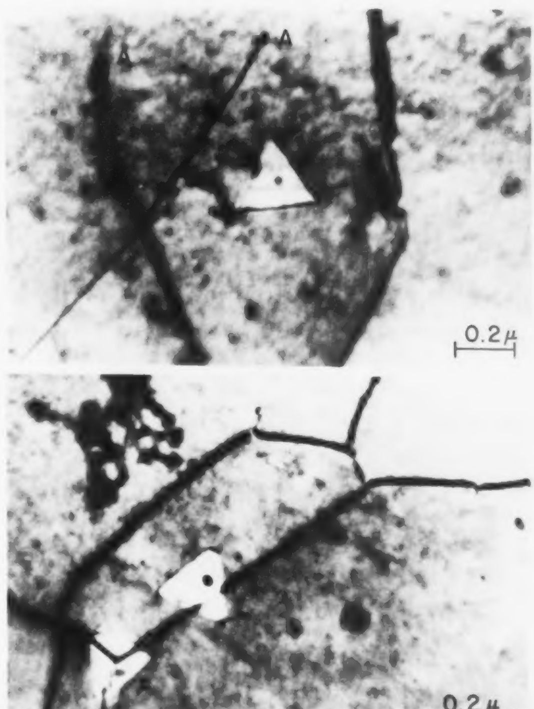
The specimens used in the experiments were single crystal sheets made from high-purity copper, grown from the melt under vacuum, and seeded so that the major flat surface was the {111} plane, that is, the close-packed plane in a face-centered-cubic structure. To obtain thicknesses in the 1000-Å range, the foils were electropolished in phosphoric acid using plane-parallel electrode geometry. Almost all of the original material was removed so that small specimens could be obtained with the desired thickness. The specimens were mounted on supporting grids in an electron microscope specimen holder. Subsequent examination by means of 100-kv electrons revealed considerable areas thin enough for transmission.

The specimens were observed either in the as-grown state or after they had been deformed by controlled amounts to introduce additional dislocations. When they had been mounted, they were immersed in the etching solution for a few seconds and then carefully washed and dried. The same etching solution ($1\,M\ (NH_4)_2S_2O_8 + 6\,M\ NH_4OH + 0.3\,M\ NH_4Br$) used by an earlier investigator [3] was employed to permit a valid independent comparison.

The techniques of transmission electron microscopy as applied to studies of dislocations in metals was developed in 1956 at the University of Cambridge. As



Electron microscopy was used to study the surfaces of copper single crystals etched in an aqueous solution. *Top:* **Carbon replica of one surface delineates the pyramidal structure of the etch pits.** *Center:* **Photomicrograph of an etched copper single crystal obtained by means of transmission electron microscopy. A short glide dislocation is associated with the etch pit** *(center of photo)*. **The points of two dislocations** ***(A)*** **that have emerged to the surface of the specimen are not pitted.** *Bottom:* **Photomicrograph of a dislocation network in an undeformed copper single crystal as observed by transmission electron microscopy. The lower etch pit** ***(A)*** **has been nucleated by the network.**



the primary contrast mechanism in this technique is due to Bragg diffraction, any lattice defect which disturbs the local diffracting conditions can be imaged. The atomic displacements associated with dislocations may be described as angular tilts of lattice planes that disturb the diffracting conditions in the area studied, and the dislocations present appear as dark lines about 100 Å thick. Etch pits extending in from the surface of the specimen are revealed by the same mechanism, and they are enhanced by the additional transmission obtained at their sites because of reduced specimen thickness.

The experiments showed that the majority of line dislocations present did in fact nucleate chemical attack at their surface intersection points. However, some dislocations were found—particularly in the as-grown specimens—that did not give rise to etching under similar conditions. In this case, it was felt that impurity atmospheres surrounding these dislocations may have inhibited the reaction. In addition, isolated etch pits were found where no observable defect existed. This phenomenon, occurring most frequently in the heavily deformed specimens, led to the conclusion that other types of defects may have nucleated chemical attack. Small dislocation loops were observed in numbers sufficiently large to partially explain such attack.

These results suggest that dislocations in metals cannot be accurately determined solely by etching methods, as a direct correspondence may not occur. Also, it appears that slight changes in the chemical solution employed may induce marked changes in the resulting attack. The results further indicate that the techniques employed in the present study may be quite useful in studies of the corrosive processes in crystalline materials, particularly the effects of lattice defects on these processes.

---

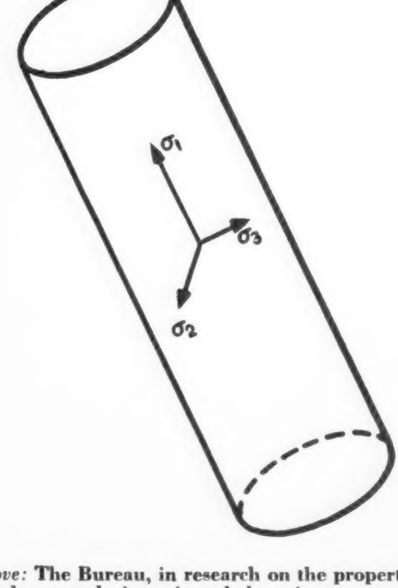
[1] *For further technical details, see* Dislocations and chemical etch pits in copper, *by A. W. Ruff, Jr., J. Appl. Phys.* **33,** *3392 (1962).*

[2] Etch pits at dislocations in copper, *by J. D. Livingston, J. Appl. Phys.* **31,** *1071 (1960).*

[3] Etch pits at dislocations in copper, *by F. W. Young, Jr., J. Appl. Phys.* **32,** *192 (1961).*

Residual Stresses in Metals

Two Concepts Compared



AN UNDERSTANDING of the residual stresses (microstresses) in metals is basic to the solution of many problems of metal behavior. When such stresses are calculated from shifts in X-ray diffraction peaks, the generally accepted theory holds that the component of stress normal to a metal specimen surface is zero. Recently, however, some experiments have provided evidence that the normal component does make a contribution to residual stress. These experiments also indicated that compressive residual stresses are induced in a deformed specimen by compressive strain.[1]

Above: **The Bureau, in research on the properties of materials, recently investigated the microstresses arising in metals from uniform uniaxial plastic deformation. This model of a deformed tensile specimen of circular cross section shows the principal microstresses related to the geometry of the specimen; that is, microstress σ_1 is axial, and σ_2 equals σ_3.** *Right:* **Point-by-point determinations of diffracted X-ray intensities are used to measure the very small changes in diffraction angles that show the state of strain in deformed metal specimens. Here C. J. Newton records such X-ray intensity data obtained with the pre-set electronic counter and timer of a diffractometer** *(in background).*

As both of these findings are in disagreement with previous NBS work,[2] C. J. Newton of the metallurgy laboratory made a comparative study of the two concepts. Purpose of the study was threefold: to attempt an evaluation of a surface-normal stress relaxation factor; to investigate the proposal that compressor strain induced residual compressive stress; and to employ a precise diffractometer method of X-ray strain measurement to appraise the validity of the procedure for calculations of internal stress systems.[3]

A high-strength steel was chosen for the experiments. It contained, in addition to iron, 0.28 percent carbon, 0.92 percent chromium, 0.50 percent manganese, and smaller amounts of a few other elements. From this material, cylindrical tensile specimens with a reduced diameter of 0.505 in. and a gage length of 2 in. and similar compressive specimens were prepared and stress-relief annealed at 1300 °F for one hour. After the annealing treatment, certain specimens were plastically deformed in tension and others in compression. Sections were then cut from the reduced areas of each specimen on two principal planes of the hypothetical residual stress system—one parallel to the axis of loading and the other perpendicular to the axis. A third section was cut at a 45-degree angle to the axis.

These X-ray diffraction specimens were mounted so that the appropriate section surface was exposed, and the surfaces were polished until no distortion remained. An X-ray diffractometer with an electronic proportional counter was employed to obtain highly precise measurements of point-by-point X-ray intensities. Both cobalt and chromium radiation sources were used under separate experimental conditions.

Conventionally Calculated Residual Stresses

Specimen	Stress component	Stress ($\times 10^3$ psi)	
		Co rad.	Cr rad.
Tensile	Axial	−22	−10
	Transverse	16	21
Compressive	Axial	32	13
	Transverse	−15	−12

With the cobalt radiation, the [310] crystallographic plane diffraction at a 2θ angle near 161 degrees was determined; with the chromium radiation, the [211] plane diffraction near 156 degrees was determined. The positions of the peaks of the diffraction lines were determined analytically by parabola fitting to three points at which the intensity had been accurately obtained. The change in the peak 2θ angle position was then determined as a function of the change in the angle between the normal to the surface of the specimen and the normal to the diffracting planes.

Attempts to fit the diffraction data to the recently reported formulas (see footnote 1) yielded unrealistic surface-normal relaxation factors—in one instance an impossible value greater than unity—and, consequently, highly improbable values of calculated stress. On the other hand, the axial and transverse residual stresses calculated with conventional formulas from the same data (see table) were reasonable in magnitude and relatively self-consistent. The stresses revealed by the two different radiations bore the same sign in all cases, with those revealed by the less penetrating chromium radiation being smaller in magnitude for the most part than those revealed by cobalt radiation, as might be expected. Even more significant, the axial residual stress after plastic compression was always found to be tensile, in contrast to the recently published results (see footnote 1).

Measurements and calculations of stresses in various directions on any one particular specimen surface showed excellent agreement between observed values and the quadric equation for stresses in isotropic homogeneous elastic theory. Measurements on the longitudinal and transverse sections also yielded results (in calculations of principal stresses with conventional formulas) that were consistent with the geometry and deformation history of the specimens. However, the values obtained for these two sections were not numerically compatible with those obtained on the 45-degree sectioned specimens, possibly because the sectioning process disturbed planar stress components on planes cut randomly in the deformed test specimen.

---

[1] On microstresses occurring in plastic deformation of polycrystalline specimens, *by D. M. Vasil'ev, Zhurnal Teknicheskui Fiziki* **28,** *2527–42 (1958); English Translation in J. Tech. Phys. USSR* **3 (28),** *2315–28 (1958). Also,* microstresses created in metals during plastic deformation II, *by D. M. Vasil'ev, Fiziki Tverdogo Tela* **1,** *1736–46 (1959); English Translation in Soviet Physics, Solid State* **1,** *1586–95 (1960).*

[2] Residual lattice strains in sectioned bars of plastically deformed iron, *by C. J. Newton and H. C. Vacher, Trans. AIME J. Metals* **7,** *1193 (1955)*; The Bauschinger effect and residual microstresses in alpha brass, *by C. J. Newton, J. Research NBS* **65C** *(Eng. & Instr.) No. 4, 265 (1961); also,* Residual stresses in brass and the Bauschinger effect, *NBS Tech. News Bull.* **45,** *199 (1961)*

[3] *For further technical details, see* Residual stresses and their relaxation on the surfaces of sections cut from plastically deformed steel specimens, *by C. J. Newton, J. Research NBS* **67C** *(Eng. & Instr.), No 2 (April–June 1963).*

NBS Plans Precision Measurement Seminars

ONE OF the more important NBS responsibilities is the dissemination of information concerning standards, calibration, and measurement techniques to American science and industry. This responsibility is being met through publication in both Bureau and outside journals, through cooperation with technical and standardizing associations, and through direct contact between NBS staff members and persons who are active in the field of precision measurement. To provide an opportunity for more extensive personal contact of this kind, the Bureau has tentatively scheduled a series of Precision Measurement Seminars.

These seminars, planned to last from a few days to no more than two weeks, depending on the subject, will be held at both the Washington and Boulder (Colo.) Laboratories of the Bureau. They will provide an opportunity for a limited number of qualified senior people from measurement laboratories to benefit from the Bureau's long experience in certain measurement areas. The seminars will combine lecture and discussion sessions with, where desirable, experience in the laboratory, and will stress the techniques of precision measurement. Attendees, while at the Bureau, will be in the status of visitors. No charge will be made for attendance at the seminars.

If sufficient interest is shown, seminars will be offered in the following areas:

- Acoustical measurements (W)*
- Attenuation measurements at communications frequencies (B)
- Frequency comparison techniques (radio frequencies and atomic standards) (B)
- Length measurements (W)
- Precision and accuracy in measurement and calibration (W)

Details concerning each of these tentative seminars are contained in the section below.

Acoustical Measurements (W)

Brief Description: The seminar will cover the primary and secondary pressure and free-field calibration of microphones at low sound pressure levels from about 1 to 20,000 c/s, the calibration of earphones with application to audiometry, and noise measurements in reverberant sound fields at low and intermediate sound pressure levels. Special experimental techniues will be described and laboratory demonstrations included.

Prerequisites: Candidates should have a background in physics, acoustics, and mathematics comparable to that received in an engineering school, should have a general familiarity with electronics systems used in laboratory measurements, and should currently be responsible for acuostic measurements of high precision.

Preparation should include a study of American Standards Association Standard 224.4–1949, *Pressure Calibration of Laboratory Standard Pressure Microphones*, and chapters 4 and 14 of *Acoustic Measurements*, by L. L. Beranek (John Wiley & Sons, Inc., 1949).

Attendance will be limited to a maximum of 15.

Tentative Dates: December 4 to 6, 1963.

Attenuation Measurement (B)

Brief Description: A survey of selected methods of measurement will include audio, IF, and RF substitution methods, modulated subcarrier, power ratio, and self-calibrating techniques. Measurements over a wide frequency range will be considered for both rectangular and coaxial waveguide systems. Emphasis will be on the highly developed techniques in use at NBS with particular attention being given to limitations imposed by the effects of crystal linearity mismatches, frequency and amplitude stability of power sources, phase shift, and standard attenuator design, as well as other sources of error in calibration systems. Performance requirements of interlaboratory standards will also be discussed. Theoretical discussions will be supplemented with laboratory demonstrations.

Prerequisites: Candidates must have undergraduate college-level training in engineering or physics or equivalent experience and must be engaged currently in precision attenuation measurements at a professional level. Attendance will be limited to approximately 25 people and will be divided into subgroups for the laboratory demonstrations.

Tentative Dates: October 21 to 25, 1963.

Frequency Comparison Techniques (B)

Brief Description: Lecture and demonstrations on atomic frequency standards, techniques used in calibrating high quality standards with precisions of a few parts in 10^{12}, discussion of factors that influence the accuracy and precision of the measurements, importance of spectral purity in high precision standards and how to measure it, lectures and demonstrations of methods of receiving and usuing HF, LF, and VLF standard frequency and time signal broadcasts, time calibrations, intercomparison of frequency standards, and laboratory

*(W) indicates seminar to be held in Washington, D.C.; (B) indicates seminar to be held in Boulder, Colo.

frequency comparison methods.

Prerequisites: Candidates must have college-level training in engineering or physics and be currently engaged in precision frequency comparisons at a professional level. Group will be limited to 15.

Tentative Dates: October 9, 10, and 11, 1963.

Length Measurements (W)

Brief Description: Topics to be covered include interferometric absolute length determination, with particular attention given to light sources, wringing interval, and aperture, phase and ambient corrections—application to gage block and meter length calibration. Interferometric methods of calibration of flatness, surface finish, diameter, and length comparison are covered. Optical and mechanical methods of dimensional metrology as applied to length, angle profile, surface finish, as well as deformation, contact pressure, and elastic limit are given special attention. Experimental and statistical programs for determination of systematic, random, and instrumental error are discussed. Theoretical development will be supplemented with laboratory demonstration.

Prerequisites: Candidates must have undergraduate college-level training in engineering or physics and must be currently engaged at a professional level in precise dimensional metrology. Preparation should include review of NBS Handbook 77, Vol. III, p. 1–350: Physical optics; e.g., Ditchburn, *Light* Chap. I–V, VIII, IX, XIII, XIV; engineering optics; e.g., Habell and Cox, *Engineering Optics*, Chap. IV–VIII. Group will be limited to ten, selected on basis of academic qualification and experience.

Tentative Dates: October 14 to 18, 1963.

Precision and Accuracy in Measurement and Calibration (W)

Brief Description: Measurement—qualitative and quantitative aspects. Errors, residuals, precision, and accuracy; quality control of a measurement process, control charts; measurement of the precision and assessment of the accuracy of a measurement process; expression of the uncertainties affecting a measurement value; propagation of error, recording of data, and protection against outlying data; and experimental designs for calibration.

Prerequisites: Applicants must have undergraduate college-level training in engineering or physics and must be currently engaged at a professional level in metrology or calibration. Preparation should include review of "ASTM Manual on Quality Control of Materials" Special Publication 15C, and "Use of the terms precision and accuracy as applied to measurement of a property of a material" ASTM Designation E 177–61T, American Society for Testing and Materials; E. B. Wilson, *An Introduction to Scientific Research*, Chapters 7, 8, 9; Churchill Eisenhart, *Realistic Evaluation of the Precision and Accuracy of Instrument Calibration Systems, NBS Journal of Research* **67C**, 161–187 (Apr.–June 1963). Group will be limited to ten, selected on basis of academic qualification and experience.

Tentative Dates: November 4 to 8, 1963.

The Bureau would be glad to receive suggestions for other seminar topics that would be of interest to measurement personnel. Additional seminars may be scheduled in the future, and details will be included in later announcements.

Application Procedure

Laboratories interested in having qualified members of their staff attend any of these seminars should write to the Bureau no later than August 1, 1963. For those seminars offered at NBS Washington, write to: W. R. Tilley, Chief, Office of Technical Information, Room 500 South Building, National Bureau of Standards, Washington 25, D.C. For the Boulder seminars, write to: E. H. Brown, Education Director, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado. Letters should include information supporting the qualifications of the candidate with respect to the "prerequisites" of the seminars, and should come from the laboratory rather than from the individual candidate. Notifications concerning acceptance will be sent by mail. In the event that more applications are received for a seminar than can be accommodated, acceptance of qualified candidates will be on a first come, first served basis.

In addition to these proposed seminars, the Bureau is also offering an intensive three-week course in Electromagnetic Measurements and Standards. Further details concerning this course, which will run from July 22 to August 9, can be obtained by writing to E. H. Brown at Boulder.

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. **47**, No. 4, April 1963. 15 cents. Annual subscription: $1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

CRPL Ionospheric Predictions for July 1963. Three months in advance. Number 4, issued April 1963. 15 cents. Annual subscription: $1.50; 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

Section D. Radio Propagation. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D.C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300
(GPO)

Publications (Continued)

Nonperiodicals

Profiles of electron density over the magnetic equator obtained using the incoherent scatter technique, K. L. Bowles et al., NBS Tech. Note 169 (Mar. 16, 1963), 25 cents.

Lectures on ion-atom collisions, M. R. C. McDowell, NBS Tech. Note 185 (Mar. 15, 1963), 40 cents.

Transmission and reflection of electrons by aluminum foils, M. J. Berger, NBS Tech. Note 187 (Apr. 1, 1963), 15 cents.

Publications in Other Journals

This column lists all publications by the NBS staff as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Communications in electronics, J. Stern, Signal **16,** No. 10, 78–79 (June 1962).

Theory of the deep penetration of electrons and charged particles, L. V. Spencer and J. Coyne, Phys. Rev. **128,** No. 5, 2230–2237 (Dec. 1962).

Quantities and units for dosimetry in diagnostic radiology, H. O. Wyckoff (Symp. under the auspices of the Division of Radiological Health, U.S. Public Health Service, Washington, D.C., March 5–6, 1962), Book, Technological Needs for Reduction of Patient Dosage from Diagnostic Radiology, ed. M. L. Janower, pp. 5–9 (Charles C. Thomas, Publ., Springfield, Ill., 1963).

Precision of methods for measuring tensile strength, stretch, and tensile energy absorption of paper, T. W. Lashof, Tappi **46,** No. 1, 52–59 (Jan. 1963).

Dimensional changes in dentures, G. C. Paffenbarger, J. B. Woelfel, and W. T. Sweeney, Dental Practitioner **13,** No. 2, 64–69 (Oct. 1962).

Current trends and prospects in cryogenics, R. W. Stewart, R. V. Smith, and T. R. Strobridge, Cryogenics **2,** No. 6, 321–324 (Dec. 1962).

Tunneling between a normal metal and a superconductor, J. Harden and R. S. Collier, Cryogenics **2,** No. 6, 369–370 (Dec. 1962).

Comments on the Rosen interaction potential of two helium atoms, B. M. Axilrod, J. Chem. Phys. **38,** No. 1, 275–277 (Jan. 1963).

Effective impedance of a wire grid parallel to the earth's surface, J. R. Wait, IRE Trans. Ant. Prop. **AP–10,** No. 5, 538–542 (Sept. 1962).

Dislocations and chemical etch pits in copper, A. W. Ruff, Jr., J. Appl. Phys. **33,** No. 12, 3392–3400 (Dec. 1962).

The intensity and spectral distribution of scattered radiation from Co^{60} sources, B. Petree and J. C. Humphreys, Radiology **80,** No. 1, 120 (Jan. 1963).

Performance characteristics of turbine flowmeters, M. R. Shafer, J. Basic Eng. **84,** Series D, No. 4, 471–485 (Dec. 1962).

Experimental *gf*-values for seventy elements, C. H. Corliss, Astrophys. J. **136,** No. 3, 916–934 (Nov. 1962).

Scientific information activities at the National Bureau of Standards, W. R. Tilley (53rd Special Libraries Assoc. Conv., Metals Division, May 29, 1962, Washington, D.C.) Spec. Lib. pp. 29–34 (Jan. 1963).

Properties of a silica-reinforced polymer for dental restorations, R. L. Bowen, J. Am. Dental Assoc. **66,** No. 1, 57–64 (Jan. 1963).

Mechanical basis of diffusion, C. Truesdell, J. Chem. Phys. **37,** No. 10, 2336–2344 (Nov. 1962).

Current status of the statistical theory of mass spectra, H. M. Rosenstock and M. Krauss, Book, Advances in Mass Spectrometry 2, 251–284 (Pergamon Press, London, England, 1962).

Available heat sinks for protected underground installations, B. A. Peavy, Proc. Natl. Acad. Sci.–Natl. Res. Council Meeting on Environmental Engineering in Protective Shelters, pp. 237–248 (Feb. 1960).

The sudden ionospheric disturbance, C. S. Warwick, Book, Radio Astronomical and Satellite Studies of the Atmosphere, pp. 457–475 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1963).

Realistic estimates of error, W. J. Youden, J. Instr. Soc. Am. **8,** No. 10, 57–58 (Oct. 1962).

Thermal reactions of isobutyl radicals, W. M. Jackson, J. R. McNesby, and B. deB. Darwent, J. Chem. Phys. **37,** No. 10, 2256–2260 (Nov. 1962).

Recent experiments on liquid helium vapor pressure measurements from 2° to 4°K, G. Cataland, M. H. Edlow, and H. H. Plumb, Book, Temperature, Its Measurement and Control in Science and Industry 3, Pt. 1, 413–417 (Reinhold Publ. Corp., New York, N.Y., 1962).

Publications for which a price is indicated are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (foreign postage one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

Patents

The following U.S. Patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce:

3,072,983. Jan. 15, 1963. Vapor Deposition of Tungsten. Abner Brenner and Walter E. Reid (NAVY).

3,074,498. Jan. 22, 1963. Device for Minimizing the Effects of Mal-Centered Balance Pan Loading. Horace A. Bowman and Lloyd B. Macurdy.

3,075,018. Jan. 22, 1963. Tris-[Pentafluorophenyl]-Phosphine and Method of Making the Same. Walter J. Pummer and Leo A. Wall (NAVY).

3,078,708. Feb. 26, 1963. Tensile Cryostat. Ralph M. McClintock (AIR FORCE).

3,078,719. Feb. 26, 1963. Airplane Cabin Pressure Error or Deviation Indicator. Fidel Cordero and Richard W. Armstrong (NAVY).

3,079,080. Feb. 26, 1963. Crane Warning System. Henry L. Mason (NAVY).

3,079,505. Feb. 26, 1963. High-Pressure Optical Cell. Charles E. Weir, Alvin Van Valkenburg, and Ellis R. Lippincott.

3,022,667. Feb. 27, 1963. Adsorption Electric Hygrometer. Arnold Wexler, Albert Krinsky, and Samuel B. Garfinkel (NAVY).

U.S. GOVERNMENT PRINTING OFFICE: 1963 O—683615

O D

ons,
Jan.

37,

M.
pec-
and,

, B.
ting
pp.

ook,
ere,
The

. 8,

. R.
10,

ure-
. H.
l in
rp.,

ail-
ov-
ign
ide
be

een
as-
by

ten.

ects
nan

nos-
mer

Mc-

r or
rm-

y L.

Zell.
ott.
ter.
kel

etin